Where is the Embodiment Effect? The Hierarchical Access Priority Model

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Abstract

There are detailed theories and abundant empirical results regarding embodied cognition. However, embodiment effects are undergoing a replication crisis. Based on the hierarchical structure of embodiment tasks and the dual process property of embodiment phenomena, we propose the hierarchical access priority model (HAP). According to HAP, the generation of embodiment effects depends on the access priority of embodied variables to unconscious processes, and embodiment effects from different hierarchy levels show a contravariant relationship between effect size and stability. Theoretically, the stability of an embodiment effect is partly determined by the hierarchy of the embodied variable, and dissociation of the dual process moderates the effect size. Empirically, the hierarchical linear model analytic method should be considered for embodied research; the embodied variable could be designed as a mediating or moderating variable, and other possible masked mediating variables should be considered. HAP offers an insightful theoretical perspective for the embodiment replication crisis.

Keywords: hierarchical access priority model; embodied cognition; replication crisis; dual process.

Embodiment means that a cognitive process is deeply rooted in the body's interactions with the world (Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2004; Shapiro, 2014; M. Wilson, 2002). In the evolution of disembodied cognition, many embodiment theories have been developed, including embodied metaphor theory (Lakoff & Mark, 1980, 1999; Mark, 1987), perceptual symbol theory (Barsalou, 1999), embodied simulation theory (Gallese & Goldman, 1998), enaction cognition theory (Stewart, Gapenne, & Paolo, 2011; Varela, Thompson, & Rosch, 1992), and somatic marker theory (Damasio, Everitt, & Bishop, 1996; Damasio & Tranel, 1991). Based on these theories, many embodied phenomena have been found, including the weight-importance metaphor (Ackerman, Nocera, & Bargh, 2010), social warmth effect (Williams & Bargh, 2008), Macbeth effect (Zhong & Liljenquist, 2006), and power posing effect (Carney, Cuddy, & Yap, 2010).

However, many previous findings of embodiment phenomena could not be replicated, or, if the results could be replicated, the replicated effect size was smaller than that of the original studies (Hu et al., 2016; Liu & Liao, 2018; Ritchie, Wiseman, & French, 2012; Zwaan, Etz, Lucas, & Donnellan, 2018). This replication crisis has led to widespread doubts regarding embodiment effects. Some researchers have commented that the basic principles of embodiment theory are either unacceptably vague (e.g., the premise that perception is influenced by the body) or they offer nothing new (e.g., cognition evolved to optimize survival, emotions affect cognition, perception-action couplings are important); therefore, embodied cognition does not offer any insights of relevance to cognitive science (Goldinger, Papesh, Barnhart, Hansen, & Hout, 2016). Why do embodiment effects have abundant theoretical support but cannot be well replicated? In response to these doubts, researchers have

emphasized methodological concerns such as the rationality and transparency of study design, scientific basis of sampling, and so on. These efforts have resulted in many breakthroughs, such as open science and pre-registration systems, and the use of Bayesian statistical methods (Zwaan, Etz, Lucas, & Donnellan, 2018). As Noah and his colleagues (2018) pointed out, we need to theoretically analyze the replication crisis rather than purely discuss the statistical issues so that we can advance the development of social psychology. Along with this perspective of theoretical analysis, present article aims to discuss the variation in the generation process of embodiment effects, so as to provide a theoretical perspective for understanding the repeatability of embodiment effects and clearly locating embodiment effects.

Theoretically, embodiment effect involves two elements: embodied variables and cognitive processes. Thus, the replicating difficulty of embodiment effects should be analyzed from the attributes of these two parts. ***First***, embodied variables are outside the core cognitive variable and have a hierarchical structure. The greater the distance between the embodied variable and the core cognitive variable, the weaker the embodiment effect (Liu & Liao, 2018). Therefore, the hierarchical structure should be considered when studying embodiment effects. ***Second***, embodiment effects appear only if the embodied variable has access to unconscious processes; primary evidence regarding this has been found using the weight-importance metaphor (Skulmowski & Rey, 2017; Zestcott, Stone, & Landau, 2017) and facial-feedback effects (Noah, Schul, & Mayo, 2018). This evidence implies that the generation of embodiment effects has an accessibility preference for unconscious processes in dual process types. Combining the hierarchical structure property of the embodied variables and the unconscious process preference property of the embodiment effects, the present article proposes a

hierarchical access priority model (HAP) to clarify the basic conditions for embodiment effects, in order to help understand and solve the replication crisis.

1 Hierarchical Access Priority Model: Theoretical Connotations and Model Construction

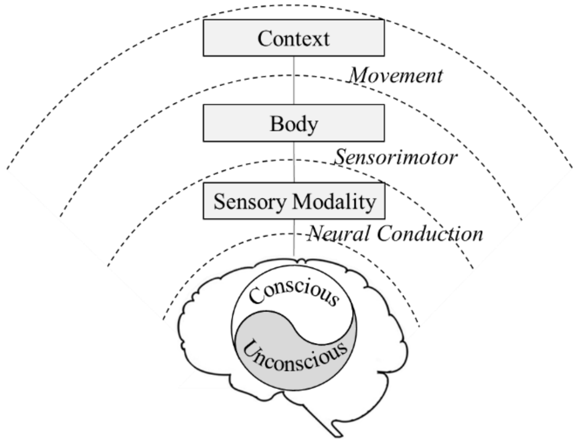

Fig. 1 Hierarchical Access Priority Model.

Here, "hierarchical" refers to the different levels of embodied variables, as shown in Fig. 1. The embodied variables from different levels are structurally connected to the brain. Generally, embodiment has three hierarchical levels: sensory modalities (such as visual response activity (Song, Vonasch, Meier, & Bargh, 2012)), body (such as the power posing effect (Carney et al., 2010; Cuddy, Schultz, & Fosse, 2018)), and context (such as the influence of regional temperature on personality (Wei et al., 2017)). Sensory modality and body levels are connected by sensorimotor activities, while body and context levels are connected by movement, and they all are connected to core cognitive processes by neural conduction. In the natural state, the farther the hierarchy is from the brain, the smaller the effect on the cognitive processing activities. However, the speed of change will be slower and the effect will be more stable. Therefore, although embodied variables from the context have little effect on core cognitive processing, their effects are very stable. On the contrary, embodied variables acting only on sensory modalities have great influence on core cognitive processing but change

rapidly, and their effects are the most unstable and difficult to measure (Liu & Liao, 2018).

"Access priority" means that a necessary condition of embodiment effects is that the embodied variable accesses the unconscious process. Modern science has already demonstrated that the core cognitive processing activities are mainly located in the brain. Thus, given that variables from the body and the context influence core cognitive processing activities, they must access the brain to generate their effects. Recent research has indicated that embodiment effects disappear when the embodied variable undergoes conscious processing, leading to speculation that the agent might consciously exclude embodiment effects (Noah et al., 2018; Skulmowski & Rey, 2017; Zestcott et al., 2017). Therefore, if embodied variables have access priority to unconscious rather than conscious processes, their effects are stronger and more stable.

The HAP model combines the hierarchy properties of different embodiment effects and the unconscious access priority property, contributing to our understanding of embodiment effect variation and the causes of the replication crisis.

The first contribution of the HAP model is that it emphasizes the hierarchy property for the first time. Ecologically differentiating embodiment effects at specific levels facilitates understanding the heterogeneity of embodiment effects. This approach was inspired by the task analysis methodology proposed by Wilson and Golonka (2013), integrating all cognitive resources and process procedures involved into the model. The division between context and body is based on biological characteristics, which naturally delineate the boundary of context and self. Embodied variables from these two levels have different types of influence on cognitive processing. The former acts on physical receptors indirectly and immersively, for

instance, the influence of regional temperature on personality (Wei et al., 2017); the latter interacts with the surroundings directly and visually through physical receptors and effectors, such as in the power posing effect (Carney et al., 2010; Cuddy et al., 2018). The body and sensory modality levels are connected by sensorimotor activities. Variables from the body level, such as body posture, are external to the body and directly observable, while those from the sensory modality, such as visual reactions, are internal to the body and not directly observable (Banerjee, Chatterjee, & Sinha, 2012; Sherman & Clore, 2009; Song et al., 2012). Therefore, embodied variables from the context, body, and sensory modalities could be differentiated based on natural ecological features, and separate investigation of the form, strength, and stability of their effects on core cognitive processing could deepen our understanding of embodiment effect variation and the replication crisis.

The second contribution of the HAP model is the suggestion that embodiment effects appear only when the embodied variables access unconscious rather than conscious processes. In classical implicit cognitive tasks, the latency is longer when the unconscious automatic process is in conflict with the conscious controlled process than when the two processes are coordinated. When embodied variables interact with core cognitive processing, the agent does not consciously notice that effect (path ① of Fig. 2). Although the agent does not directly notice the embodiment effect, if they are told about that effect, it could be excluded by a conscious process (path ② of Fig. 2). Research on the weight-importance metaphor (Skulmowski & Rey, 2017; Zestcott, Stone, & Landau, 2017) and facial-feedback effects (Noah, Schul, & Mayo, 2018) have demonstrated this reaction pattern.

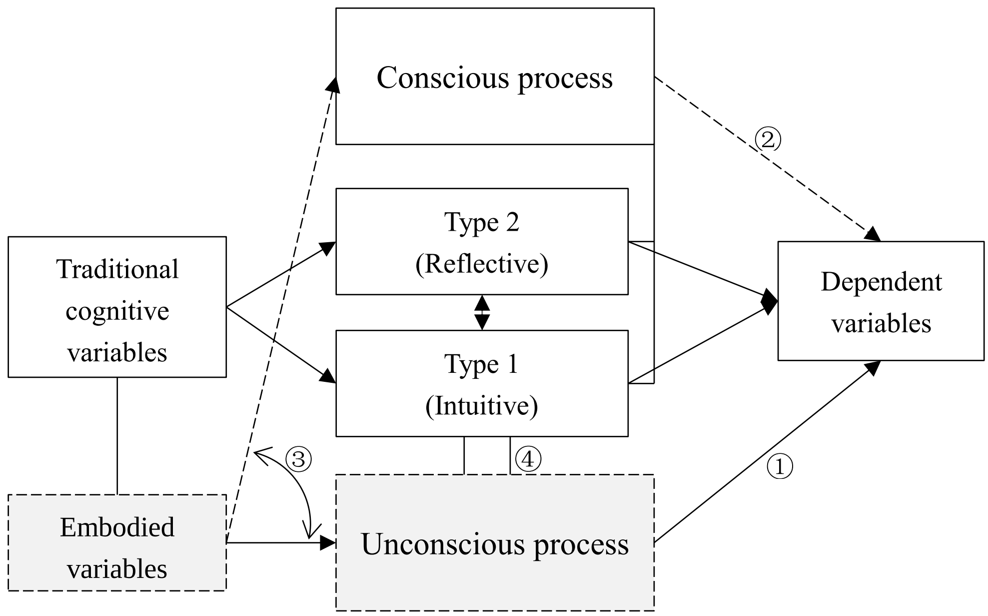

Fig. 2 Relationship between embodied dual process and traditional dual process framework.

The embodied dual process has been further developed based on traditional dual process theory. Evans and his colleagues argue that Type 1 processes are autonomous and independent on working memory, while Type 2 processes involve higher-order reasoning, requiring hypothetical thinking and relying heavily on working memory (Evans & Stanovich, 2013; Pennycook, De Neys, Evans, Stanovich, & Thompson, 2018). It is worth noting that the relationship between Type 1 and Type 2 (conflict or coordinate) can be consciously controlled by the subject, while unconscious processes (such as the process of an embodied variable) are outside their control. A switching between the conscious and unconscious state can occur, as shown in path ③ of Fig. 2. When the process of an embodied variable switches from the unconscious to the conscious state, its effect can be excluded by the subject's conscious control. Take the climate as an example. When arriving in a new place, a subject may be unadapted and consciously process the climate, possibly affecting his/her cognitive performance; after complete adaptation to the climate, the effect of climate on cognitive performance is still there

but has switched to the unconscious state and become a part of cognition; conversely, when the climate suddenly changes, its processing might become consciously controlled again. When yielding default responses (Evans & Stanovich, 2013), unconscious processes and Type 1 processes share the automatic process channel (path ④ of Fig. 2) and thus have a repulsive effect. When a core cognitive task is automatically processed by a Type 1 process, the effect of embodied variables on core cognitive performance will be crowded out and unable to access the cognitive resources. For example, although cognitive performance could be influenced by an unusual climate, this effect would be crowded out when the subject is under stress and automatically reacting to the cognitive task.

According to the HAP model, there are two main reasons for the embodiment effect's replication crisis: effect strength and stability are contravariant, which makes it hard to detect the embodiment effect; and the access priority of an embodied variable to unconscious processing is artificially switched or blocked. The HAP model can explain the replication crisis of embodiment effects via theoretical and metrical insights.

2 Theoretical Enlightenments from HAP

HAP model provides two Theoretical insights based on the analysis of embodied hierarchical structure and dual process property of cognition. ***First*****,** the stability level of an embodiment effect is determined according to the hierarchy of the embodied variable. According to HAP, an embodiment effect at the context level, such as the influence of regional temperature on personality, should generally be the most stable, (Wei et al., 2017); while the effects at the sensory modality level, such as brightness and haptic sensations, should be the least stable (Ackerman et al., 2010; Banerjee et al., 2012). The context information changes

most slowly and is mostly processed unconsciously, while sensory information changes fastest and is the most likely to be processed consciously. Similarly, even at the same level, local variables are more unstable than global variables, but their effects are stronger. For example, the temperature and humidity inside a shopping mall influence people's current clothing and mental state more than the external weather environment, but the stability of this effect is weaker than that of the external environment.

Second**,** the embodiment effect size is changed by the dissociation of dual process types. Cognition depletion, time pressure, and the dual tasks paradigm are commonly used for dual process dissociation. Based on cognitive resource limitation theory, a conscious process requires more cognitive resources and energy. So, when given enough energy (e.g., from glucose intake), sufficient reaction time, and a single task, a subject will process the cognitive task consciously, while the embodied variable will unconsciously affect the cognitive task. Otherwise, when energy is depleted (e.g., immediately after finishing a difficult Sudoku task), given time pressure and dual tasks, the subject will process the cognitive task unconsciously; this process will occupy the automatic processing channel and crowd out or block the embodiment effects (Skulmowski & Rey, 2017). If the subject is made to notice the effect of the embodied variable, such as by placing a camera on the desk or telling the subject about the effect, they will exclude the embodiment effect consciously (Noah et al., 2018).

3 Metrical Enlightenments from HAP

In the metrical perspective, the HAP model provides two recommendations. The first, regarding the applicability of the statistical model, is that the hierarchical linear model (HLM) could be considered rather than the general linear model (GLM); the second relates to the

research design and the possibility of designing the embodied variable as a mediating or moderating variable, as well as the potential existence of other masked mediating variables that could be considered.

Previous embodiment studies have mainly used the GLM or analysis of variance (ANOVA) to identify the effects of embodied variables. In fact, there are two preconditions for the GLM: that the variables are at the same theoretical level; and that the participants are randomly enrolled and independently identically distributed. As can be seen in the HAP model, embodied variables are not at the same level as the traditional psychological and behavioral variables. Also, in actual experimental studies, the participants are sometimes cluster sampled. Therefore, it is not always appropriate to use the GLM or ANOVA. As explained in Finch, Bolin and Kelley (2014), use of the GLM analysis method with nested (or clustered or embedded) data will underestimate the standard error of regression correlation and magnify Type 1 errors. The inappropriate use of the GLM to analyze embodiment data is a probable reason for embodiment effects variation.

Based on the hierarchy property of embodied variables, the HLM is more appropriate for use in embodiment effect studies. Luke (2004) proposes three conditions for HLM application: from a theoretic view, the topic is multilevel; from a statistical view, the data structure violates the assumptions of linear regression’s independence and homogeneity; from an empirical view, the intraclass correlation coefficient is too big to ignore. As in embodiment studies, the variables have theoretical hierarchy levels. This satisfies the first condition; the second and third conditions should be analyzed on a case-by-case basis. Use of the HLM should be at least considered in the data analysis of embodiment studies.

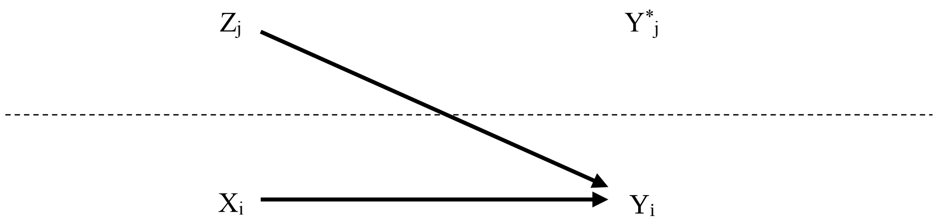

Fig. 3 Cross-level research framework for embodiment studies.

The research framework (Fig. 3) can be represented using the GLM statistical method as

(1) $Y_{ij}=\alpha_j+\beta_j X_{ij}+\gamma Z_j+e_{ij}$,

where Y_{ij} represents a dependent psychological variable, such as purchase decision-making; X_{ij} represents a traditionally discussed independent variable, such as product price; and Z_j represents an embodied variable, such as the smell of the environment. X_{ij} has two subscripts: i represents the conditions of the independent variable, while j represents the conditions of the embodied variable. Therefore, there might be different values of X_i under different Z_j conditions. α_j represents the intercept, which could be the same (also could be different) under different Z_j conditions, as is β_j. γ reflects the effects of embodied variables.

In the embodied research, the variating effect of outcome variable in traditional psychological level might refer to different hierarchies, both core cognitive and embodied levels. However, the traditional GLM cannot be used to determine the different effects. As shown in (2) to (4), the dependent effect could result from the traditional psychological level and/or the embodiment levels. Therefore, the HLM should be used in the analysis. Equation (5) is the comprehensive equation of (2) to (4), ε_{ij} is the error from the traditional psychological level, and μ_{0j} and μ_{1j} are the errors from the embodiment levels.

(2) Level 1: $Y_{ij}=\beta_{0j}+\beta_{1j}X_{ij}+\varepsilon_{ij}$

(3) Level 2: $\beta_{0j}=\gamma_{00}+\gamma_{01}Z_j+\mu_{0j}$

(4) $\beta_{1j}=\gamma_{10}+\gamma_{11}Z_j+\mu_{1j}$

(5) Mixed: $Y_{ij}=\gamma_{00}+\gamma_{10}X_{ij}+\gamma_{01}Z_j+\gamma_{11}Z_jX_{ij}+\mu_{0j}+\mu_{1j}X_{ij}+\varepsilon_{ij}$

As can be seen from (5), errors from embodiment levels are included, in contrast to the GLM. Thus, the HLM can more accurately reveal the effects of embodiment than the GLM. If the GLM is used to analyze the nested data from embodied studies, the α value should normally be enlarged to avoid amplifying statistical Type 1 errors, although this depends on the specific situation.

Besides the use of the HLM analysis method, research design needs to consider the embodied variable as a mediating or moderating variable (Lee & Schwarz, 2012; Meier, Schnall, Schwarz, & Bargh, 2012), as well as the possible existence of other masked mediating variables. In the mediating situation, the traditional independent variable affects the dependent variable indirectly through the embodied variable. In the moderating situation, the traditional relationships of psychological variables are different for different conditions of the target embodied variable. In the moderating situation, in particular, if the embodied variable is designed as an independent instead of a moderating variable, the resulting embodiment effect would not be significant. Besides, other masked mediating variables should be considered. According to the hierarchical features of embodiment, variables farther away from the core cognitive processing are unlikely to directly affect core cognitive processing process, but may have indirect effects through the sensory receptors of the body and arousal of the central nervous system, including the brain stem. Many possible mediating variables could exist. They could function in the same or opposing directions. When the total effects of independent variables on dependent variables are not significant, there is the possibility that the direct effect

and indirect effect through the mediating variables are in opposition to each other, which would suggest a masked mediating effect (Cheung & Lau, 2008; Mackinnon, Krull, & Lockwood, 2000). In embodied studies, if the independent variable is an embodied variable, while the dependent variable is a traditional mental variable, and the total effect is not significant, possible masked mediating variables should be investigated.

4 Conclusion and Future Directions

The current work constructs HAP model based on the hierarchy property of embodied variables and the dual process property. This model can explain why embodiment effects vary considerably across studies, especially in replication studies. When subjects are rushing to finish the experimental task, they rely on Type 1 processes and block the accessibility of embodied variables to the core cognitive process. According to the HAP model, theoretically, the stability of an embodiment effect is determined by the hierarchy level of the embodied variable, and the embodiment effect can be moderated by dual process dissociation; metrically, the HLM is recommended for use in nested embodied studies, the embodied variable can be designed as a mediating or moderating variable, and other possible masked mediating variables should be considered.

It should be noted that the HAP model does not explain why and how an embodiment effect occurs. Instead, it provides two main insights on the replicating difficulty: ***First***, the effect size and its stability per se have a contravariant relationship, making it hard to detect the effect. ***Second***, the access priority is changed either by occupying unconscious automatic processes and blocking the embodied variable's influence or consciously being excluded by the subject's metacognitive control. These two reasons deteriorate and even rule out the

potential for replication.

Obviously, many other factors could influence the replication of embodiment effects; these include general processing type preferences, the congruence of the embodied variable with the context, the participant's processing type preference for experimental tasks, and the arousal extent of embodied variables. However, the main contribution of the present work was to determine the basic condition for the embodiment effect: the access priority of embodied variables to the unconscious process. It also describes the embodiment hierarchy levels and cognitive process types, and, furthermore, recommends use of the HLM statistical method and study designs that include the embodied variable as a mediating or moderating variable, as well as considering other masked mediating variables. Future research could directly test the theoretical assumptions of the present work and accurately track the embodiment effects.

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Contributions: Chuanjun Liu and Jiangqun Liao developed the idea and the manuscript structure; Chuanjun Liu drafted the first edition; all the authors discussed together and revised the manuscript.